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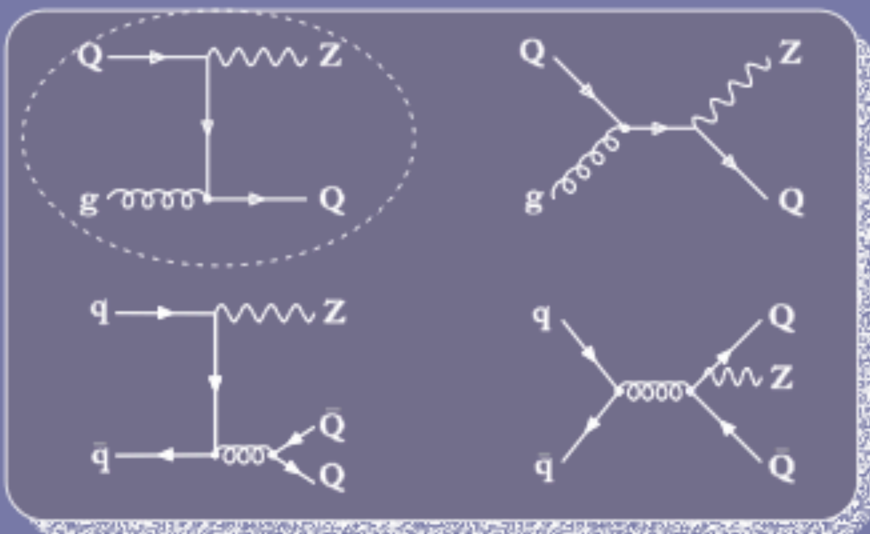
Suyong Choi (D0)

Z + single b-tag

- Z+b inclusive diagrams

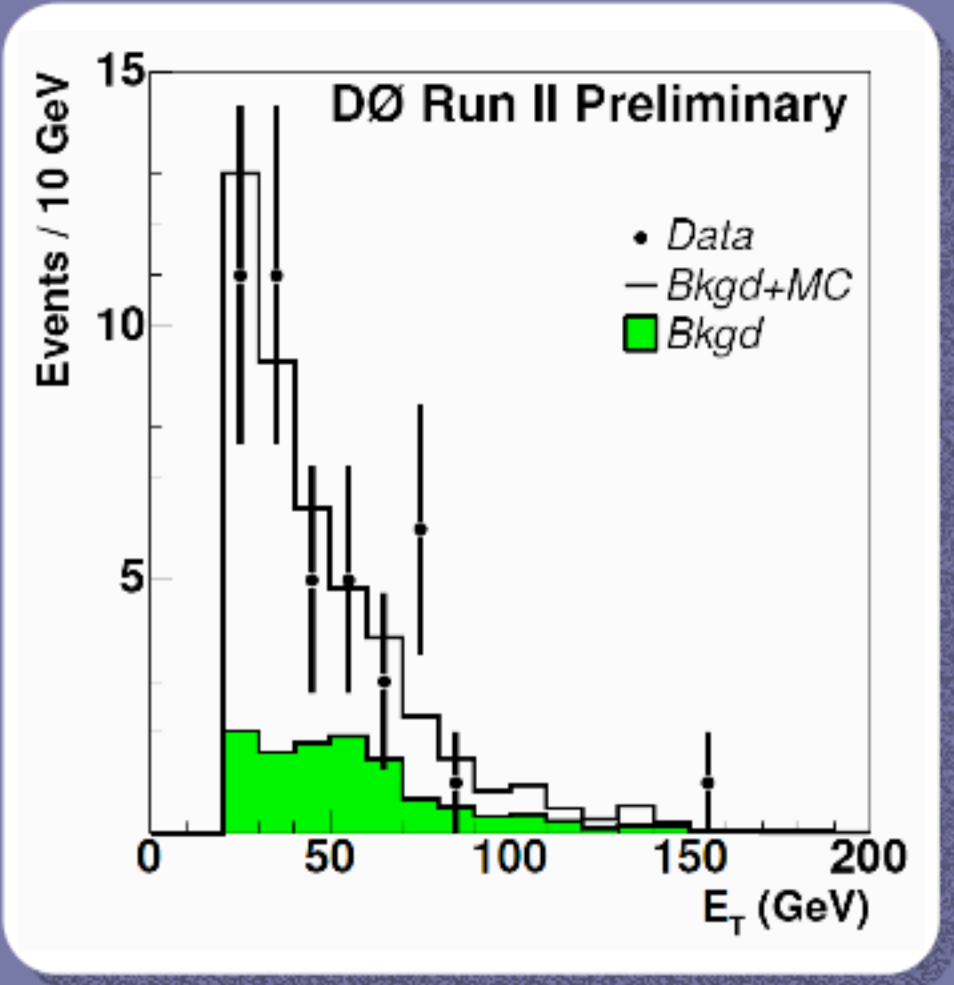


  - $gg \rightarrow Zbb$ is considered as NLO corrections to $gb \rightarrow Zb$ in the scheme of Campbell et al. PRD 69 (2004) 074021

- Background to Higgs search in ZH mode at the Tevatron
- Benchmark analysis for $gb \rightarrow hb$
- Probe of b-quark parton density
  - Hb
  - Single top
  - Charged Higgs
  - bb-bar → H
- DØ has a preliminary result of $\sigma(Z+b)/\sigma(Z+j)$

1st measurement of b dist in p!

Z+b-tag

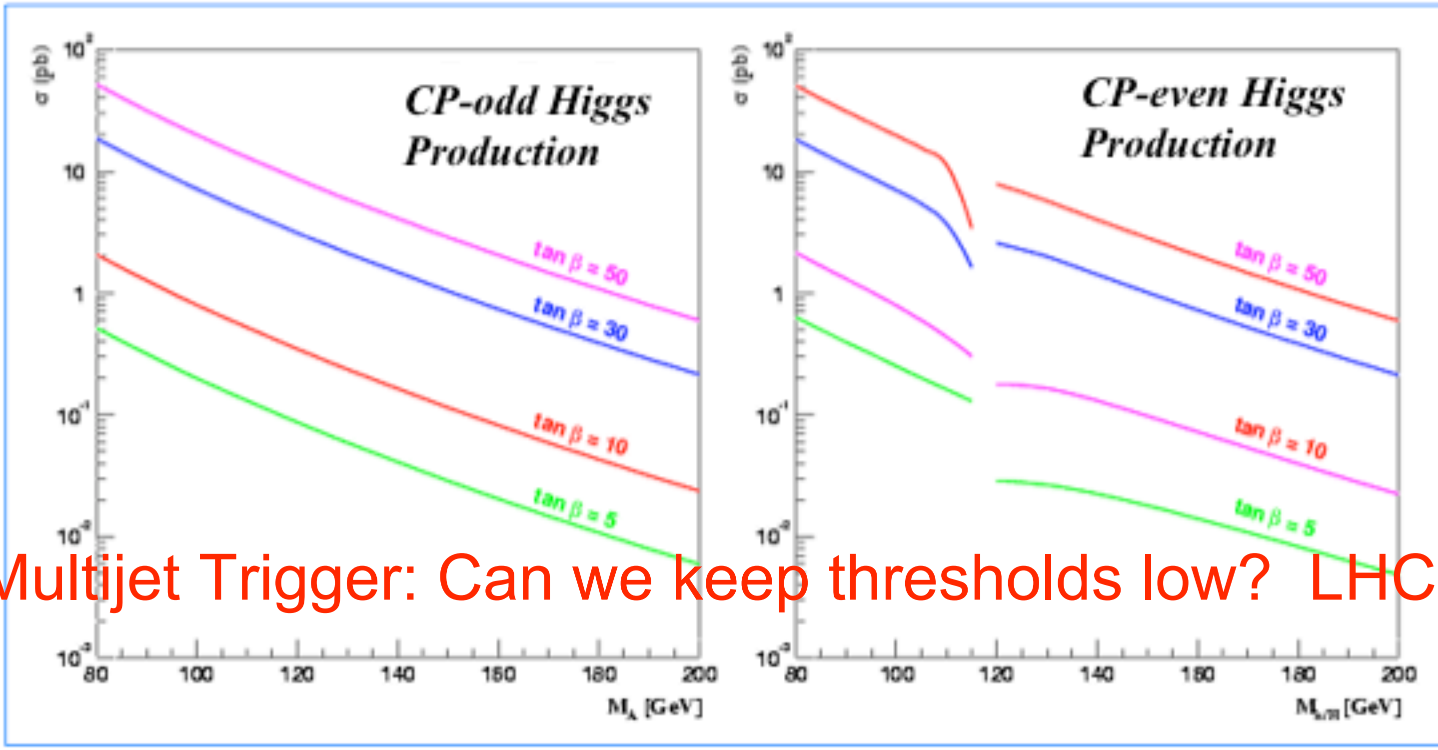


- 42 events remain after b-tagging
- Background shown in the figure is the sum of
  - Instrumental background
  - light-jet mistag
- Composition is found by solving the set of equations

With 10x stats could measure as function of x

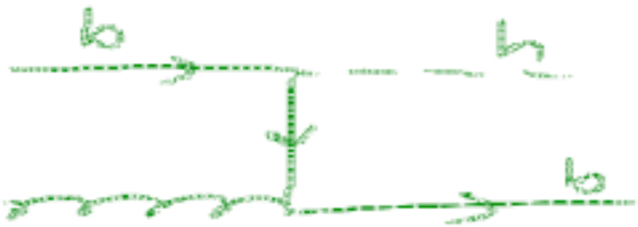
Basic assumptions: Higgs boson production at large tanβ

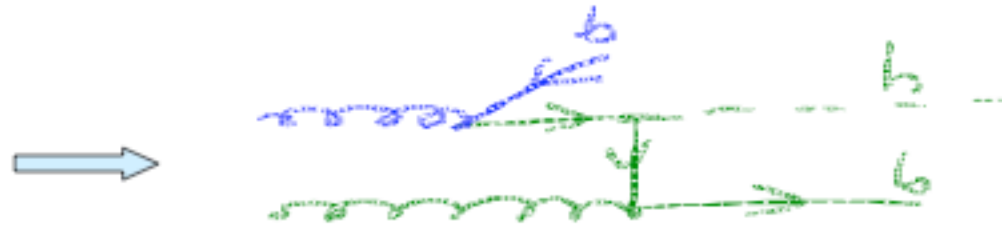
- Large tanβ → enhanced bbf (f = h, H, A) coupling
  - Cross section rises like **tan²β**
- A and (h or H) are produced simultaneously
- A, h (or H) to bb decay branching fractions are ~ 0.9
- Except for a region m_A~110 – 130 GeV depending on tanb and other MSSM pars.

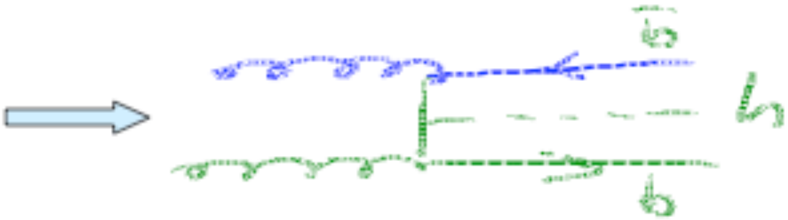


Multijet Trigger: Can we keep thresholds low? LHC??

bh vs bbh processes

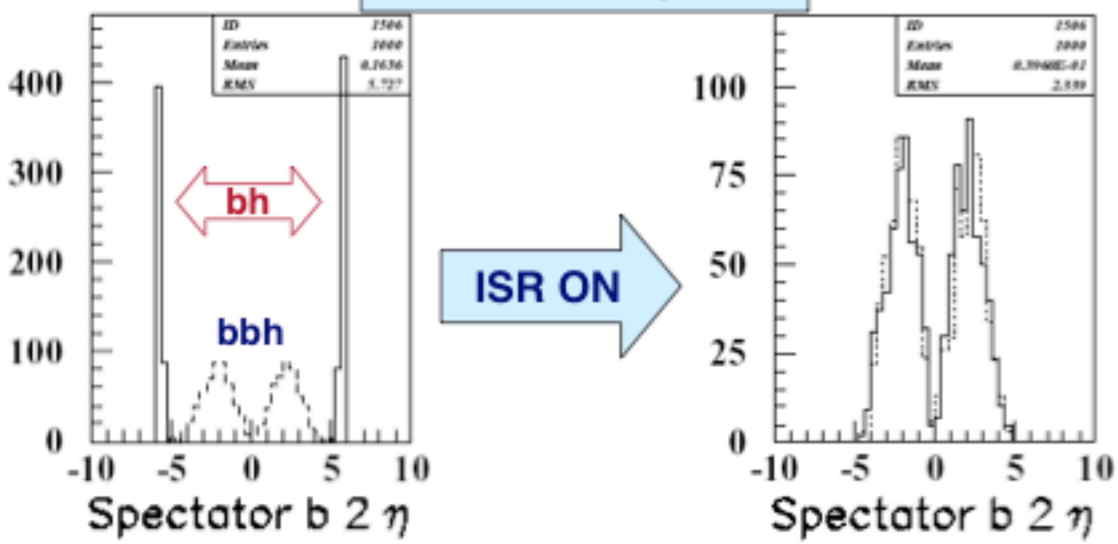






- Depending on kinematics, the 2nd spectator b might well be central

Let's ask Pythia



Almost exact overlap

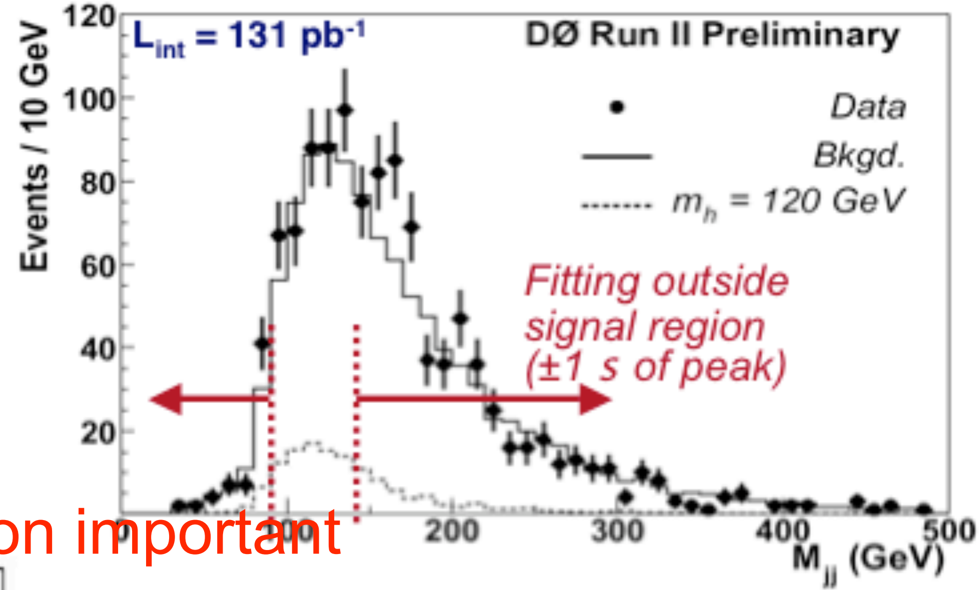
Can use bh or bbh

Use bh in the following

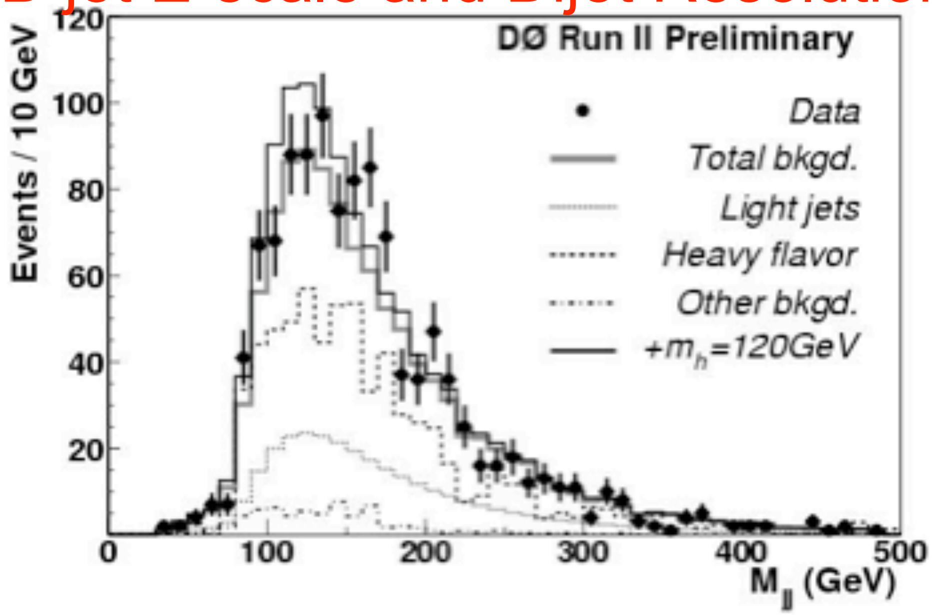
gg->bbh needs Deeper comparison to gb->bh

Triple b-tag sample

- At least 3 jets; p_T and h cuts optimized for Higgs mass and # of required jets
- Look for excess in di-jet mass
- Background shape determined from double b-tagged data by applying fake tag function to non-b-tagged jets



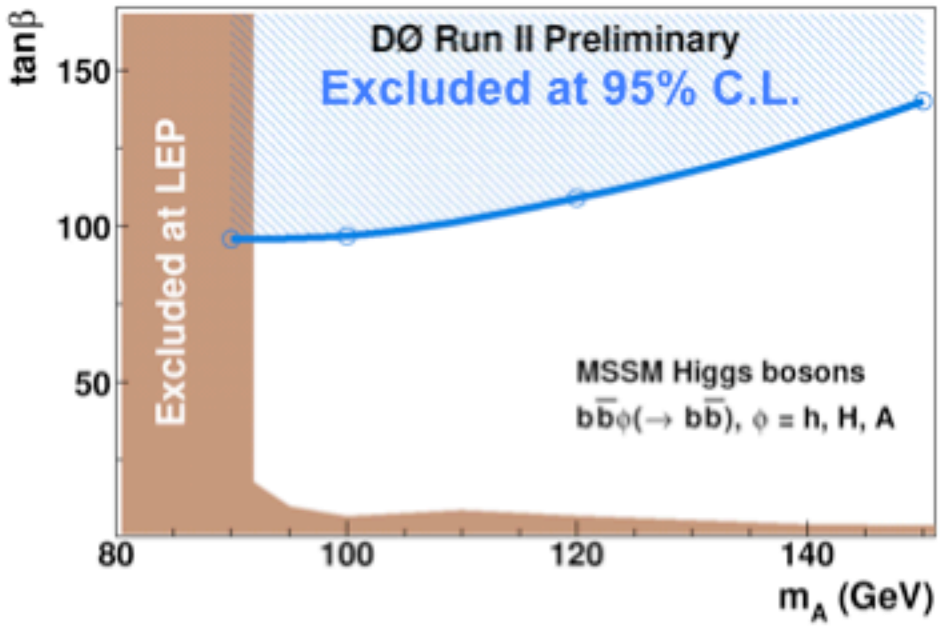
B-jet E-scale and Dijet Resolution important



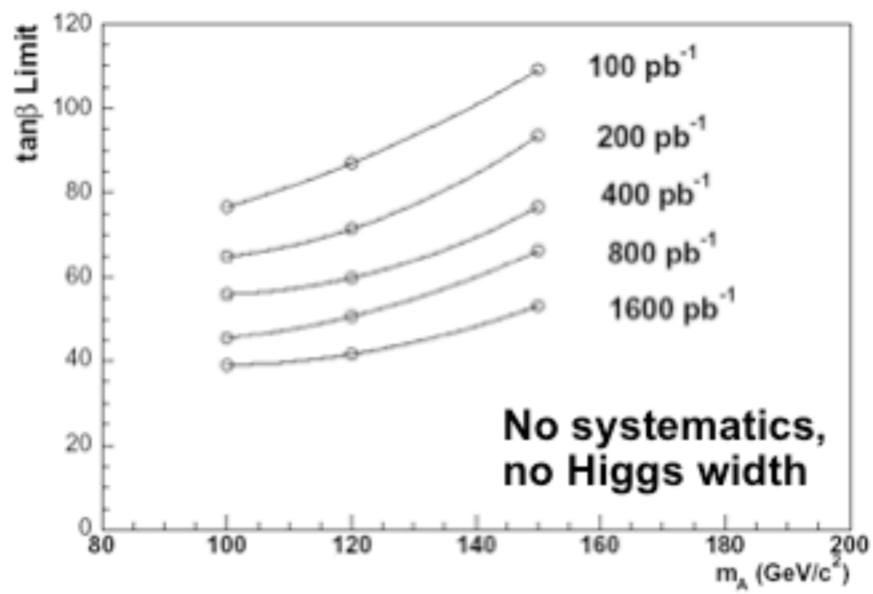
- HF production is dominant
- No additional tuning for HF fraction is required once its rate is fixed in double b-tag sample

Learned how to measure QCD Backgrounds for Higgs

bf /bbf (→bb): preliminary results

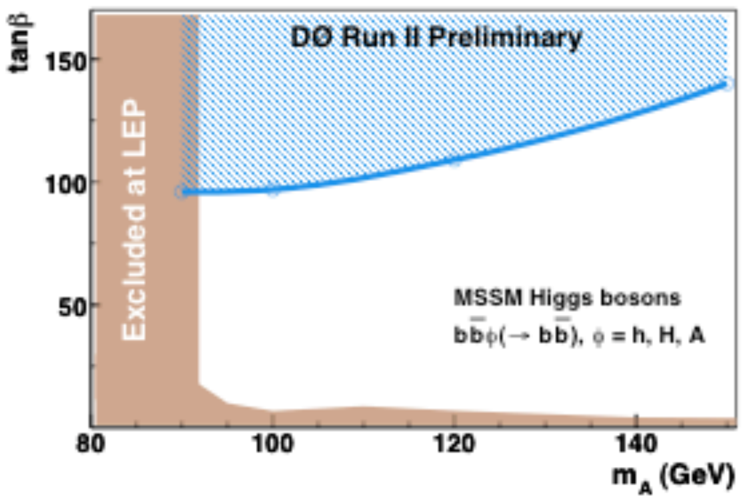


- Signal acceptance is ~ 0.2–1.5% depending on m_h and final state
- Systematics (22-28%) taken into account
  - JES, b-tagging, resolution, trigger …
  - Decay width approximated by Gaussian



- Sensitivity to tanb down to ~ 40 for m_A = 100 GeV is expected with 1.6 fb^{-1} of data and with the current assumptions and performances

DZero Run II vs. CDF Run I

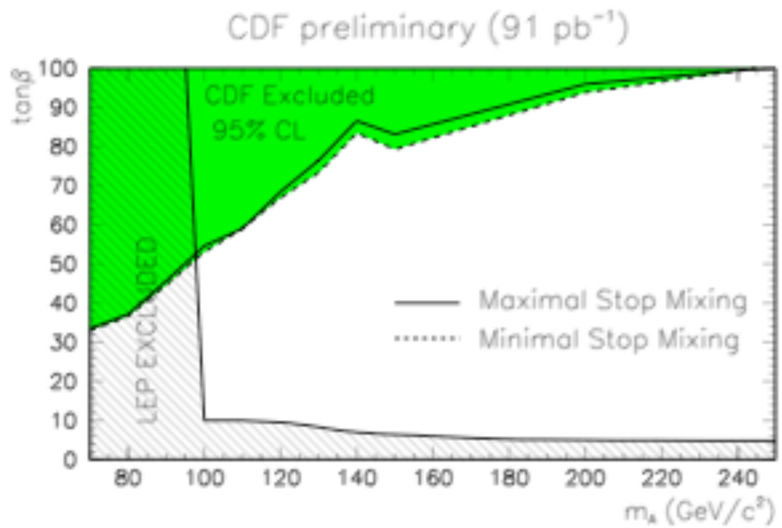


DZero Run II Limit; March 2004

Using $\underline{130\ \mathrm{pb}^{-1}}$

CDF Run I Limit; October 2000

Using $\underline{91\ \mathrm{pb}^{-1}}$



How can DZero Run II limit be worse?!

Case now closed

Effect of the PDF on Acceptance: Total (qq + gg)

PYTHIA Monte Carlo ($M_A = 90$; $\tan\beta = 50$)

		CTEQ3L(total)	CTEQ5L(total)
σ		27.04	18.31
Num MC		—	—
L2	Events		
	Accept.(%)	0.81	0.79
	$\sigma * Accept$	0.22	0.15
Kinematics	Events		
	Accept.(%)	0.13	0.13
	$\sigma * Accept$	0.035	0.023
b-Tagging	Events		
	Accept.(%)	0.015	0.010
	$\sigma * Accept$	0.0041	0.0019
bJetKin	Events		
	Accept.(%)	0.011	0.0067
	$\sigma * Accept$	0.0030	0.0012

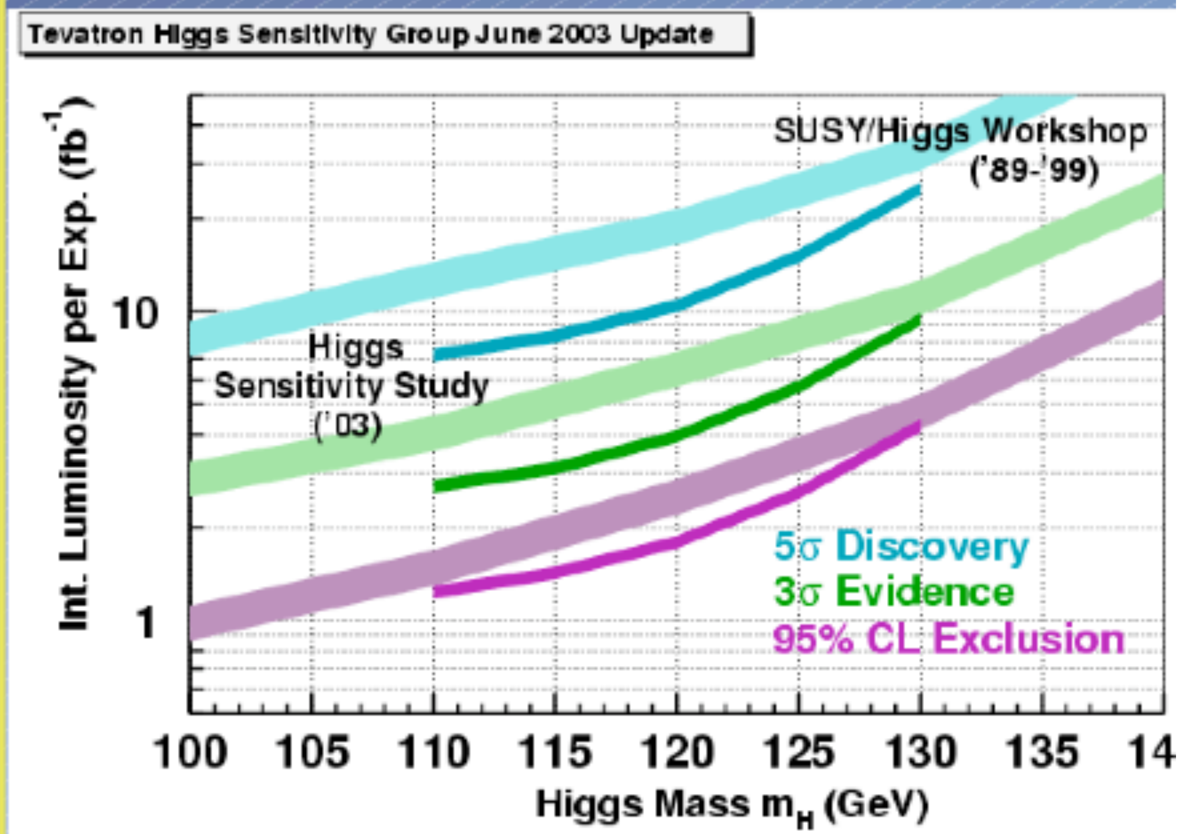
The total difference between the PDF's:

$0.0030/0.0013 = 2.5$

Why PDF effects so large?

Combined Results

- Combined DØ/CDF result
  - Assumes luminosity from two experiments
- 10% dijet mass resolution
- Run IIB silicon
- Width of HSG bands determined by method uncertainty
  - No systematics included
- Width of SHWG bands given by analysis uncertainty
- SHWG included $H \rightarrow WW$
  - contributes at high m_H



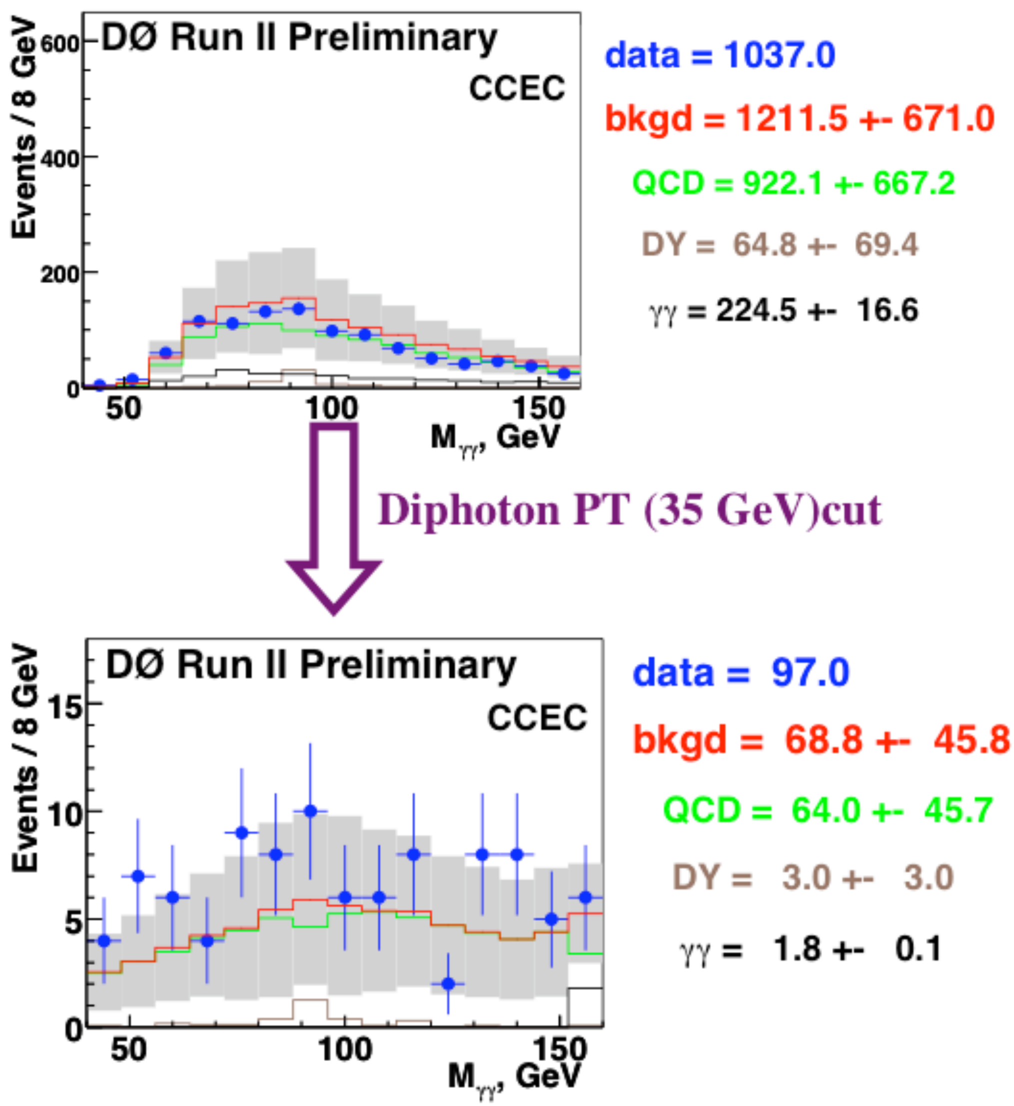
Low mass region 95% excl. or 3σ by 2008
This is difficult region at LHC

What could we do right now?

- Measurement of WZ/ZZ mass distribution
  - A combination would be sensitive to this with ~250 pb^{-1} per expt
  - Standard candle for dijet mass resolution studies
  - "Dry run" for a Higgs search (also a nice result in itself!)
- Full measurements of systematic errors
  - One of the largest complaints about the SHWG and HSG studies
  - Timescale is good for understanding these issues
  - Can be a huge factor in reducing luminosity requirements!
- Studies of final variable techniques
  - Learn from LEP (b-Tag, constrained fits, etc...)
  - Give this many smart people enough time, a lot can be thought up

Di-photon mass spectra, $\int L dt \approx 190 \text{pb}^{-1}$ ($\approx$ half of the currently available data)

Alex Melnitchouk



QCD: At least 1jet Mis-ID as γ main bkg

LHC: More material!

TeV can look at ID'd Conversions

Open Questions

Apart from a brief presentation of CDF results, the biggest questions might be:

- Does LO/NLO get the SM diphoton x-sec and p_T right ?
- How accurately can we state that?
- Is that the only significant background to the Higgs search or will dijets be a big problem?
- The latter probably can't answered by us easily, but if we look into the existing LHC work, we could probably comment on it.

  e.g.) If the fake rate seems reasonable, or

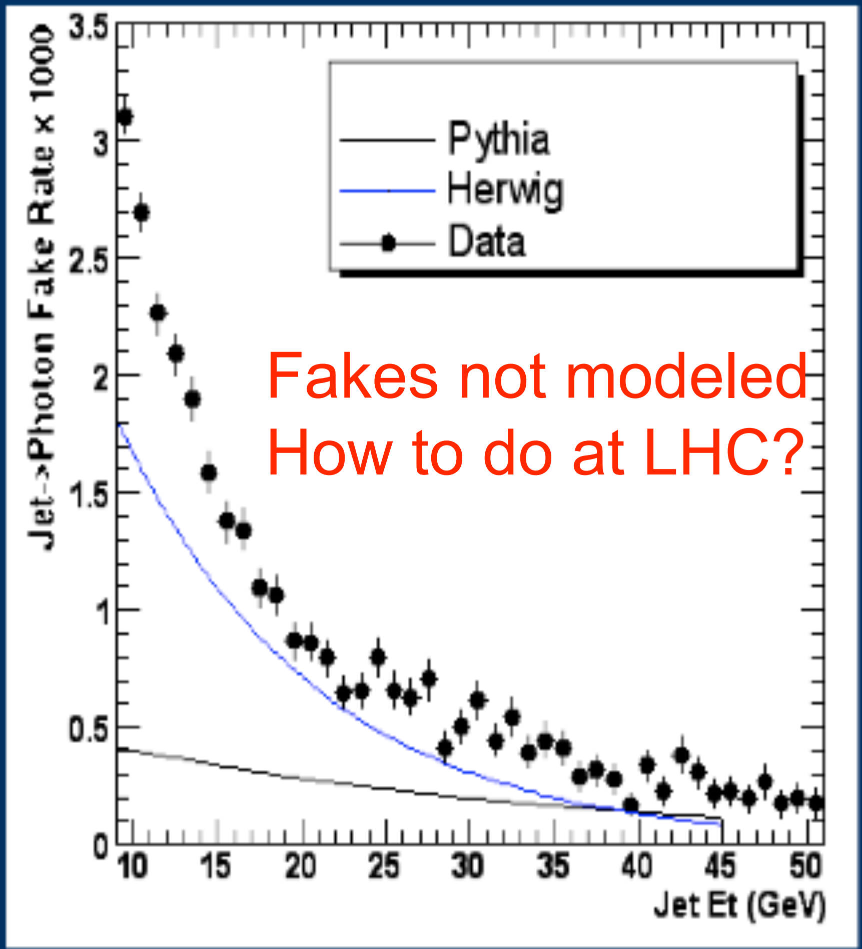
  Does CDF Monte Carlo predict the right fake rate?

Photon Fake Rate from Data

A. Nikitenko (Plenary Talk)

- Rate of jets with leading meson (π^0,η) which cannot be distinguished from prompt photons: Depends on
  - detector capabilities, e.g. granularity ofcalorimeter
  - cuts!
- Systematic error about 30-80% depending on Et
- Data higher than PYTHIA and HERWIG
- PYTHIA describes data better than HERWIG

CDF (preliminary result)

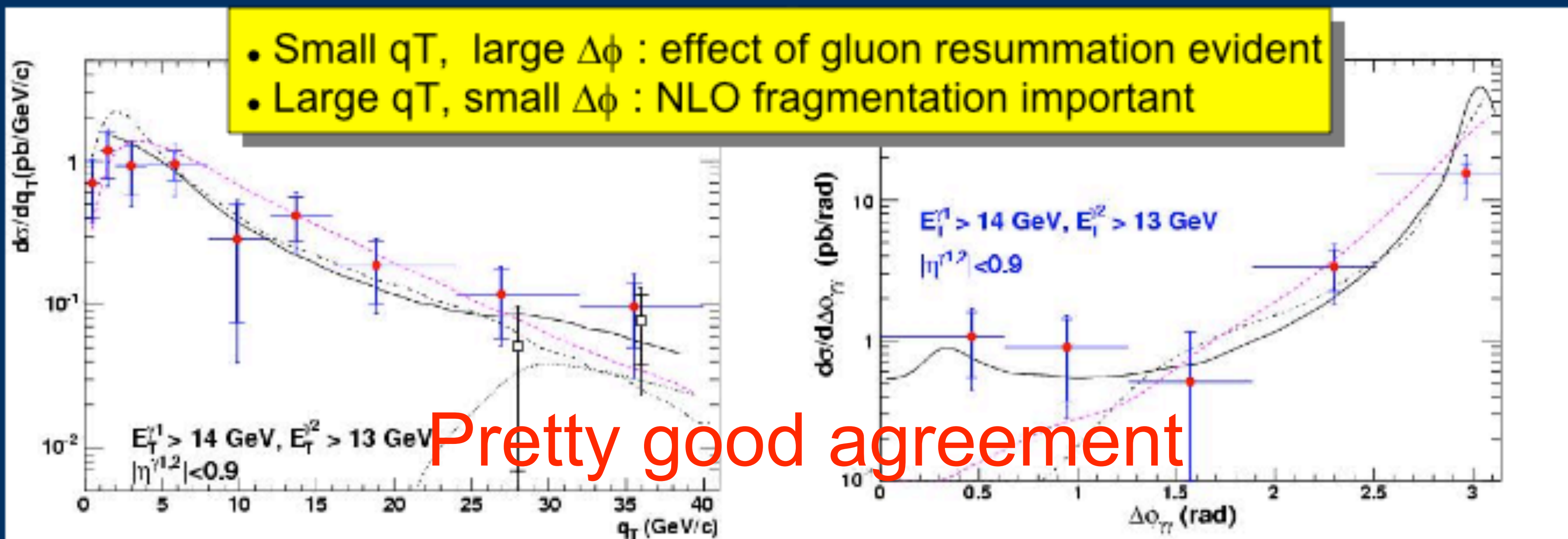


At TeV Jet→γ miss ID is obtained from γ+jet data.
We should evaluate how does it work with LHC detectors

Diphoton Cross Sections

qt = diphoton systemPt

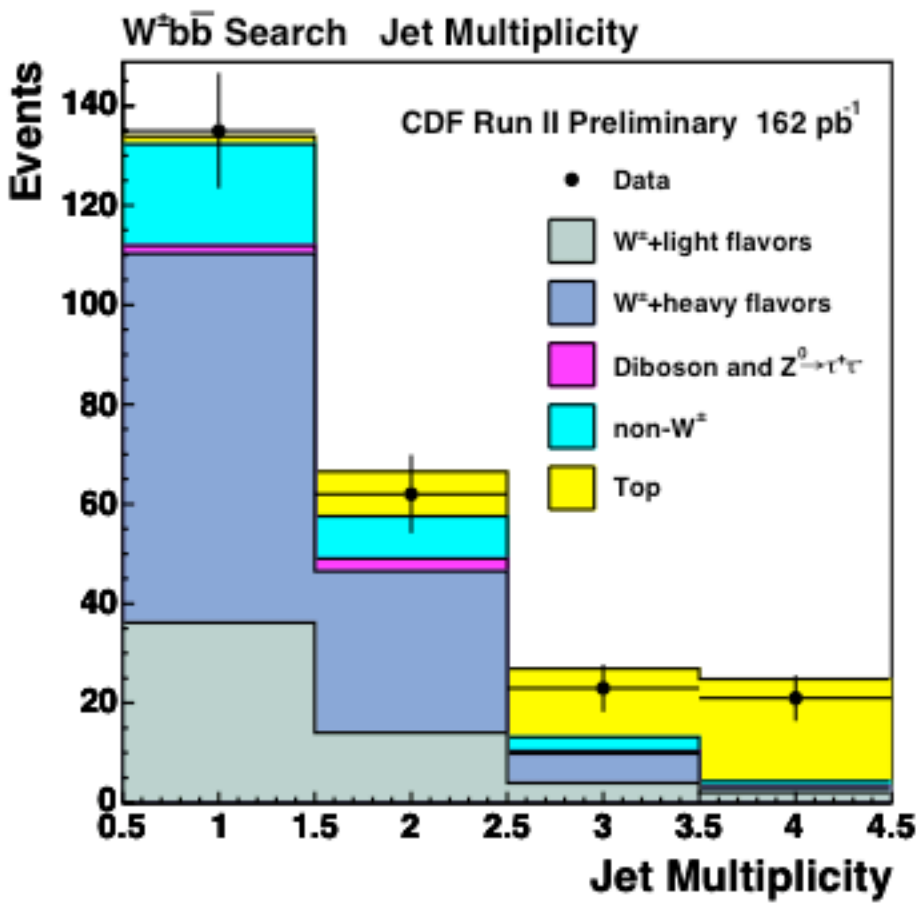
$\Delta\phi$ between photons



- LO PYTHIA low by a factor ~2.0, but reasonable mass shape
- DIPHOX breaks down at low qt due to singularities in NLO
- RESBOS does better at low qt due to continuous ISR resumming
- DIPHOX shows additional source at low m($\gamma\gamma$), small $\Delta\phi$, and qt>30 GeV. These are ($qg \rightarrow gq\gamma \rightarrow g\gamma\gamma$) where the q fragmented to a photon

Understanding W+jets is key to SM TeV Higgs Search

CDF Result (Background Estimation)



CDF Run II Preliminary (162 pb^{-1})

Background	$W^{\pm} + 2$ jets
Events before tagging	2072
$W^{\pm}+$ light flavors	14.1 ± 2.6
$W^{\perp} + b\bar{b}$	19.1 ± 5.8
$W^{\pm} + cc$	6.8 ± 2.2
$W^{\pm} + c$	6.5 ± 1.8
Diboson/$Z^0 \rightarrow \tau^+\tau^-$	2.5 ± 0.6
non-$W^{\pm}$	8.5 ± 1.2
$t\bar{t}$	5.1 ± 1.0
single top	3.8 ± 0.5
Total Background	66.5 ± 9.0
Observed positive tags	62

Br(H->bb)*σ(WH) < 5pb

- The measured numbers are consistent with estimated numbers.
- 62 tagged events in $W^{\perp} + 2$ jets bin, including 8 double tagged events.
- Reconstruct dijet mass from the 62 tagged events. $\rightarrow$ Next page.

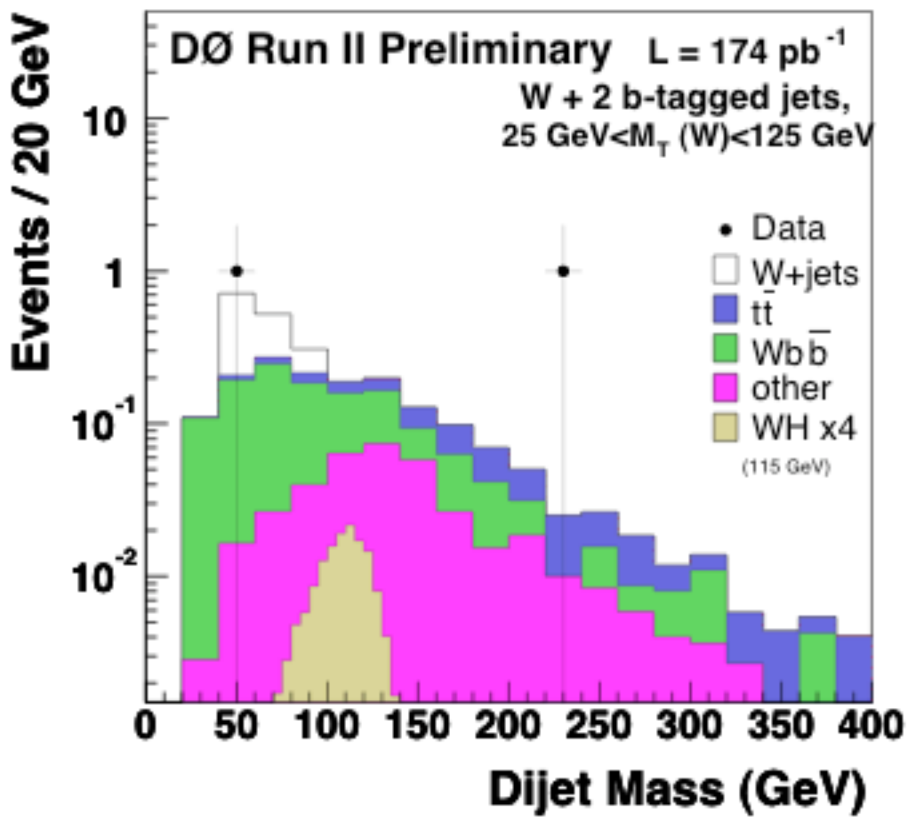
DØ Result (95% C.L. Upper Limit)

TeV search complimentary

- Besides, require the following selections:
  1. $25 < m_T(W^{\pm}) < 125$ GeV$/c^2$,
  2. Exactly two b-tagged jets to suppress top background,

  $\rightarrow$ 2 events (expect:2.5 ± 0.5).
- Set a 95% C.L. upper limit with mass window ($85 <$ Dijet Mass < 135 GeV/c^2).

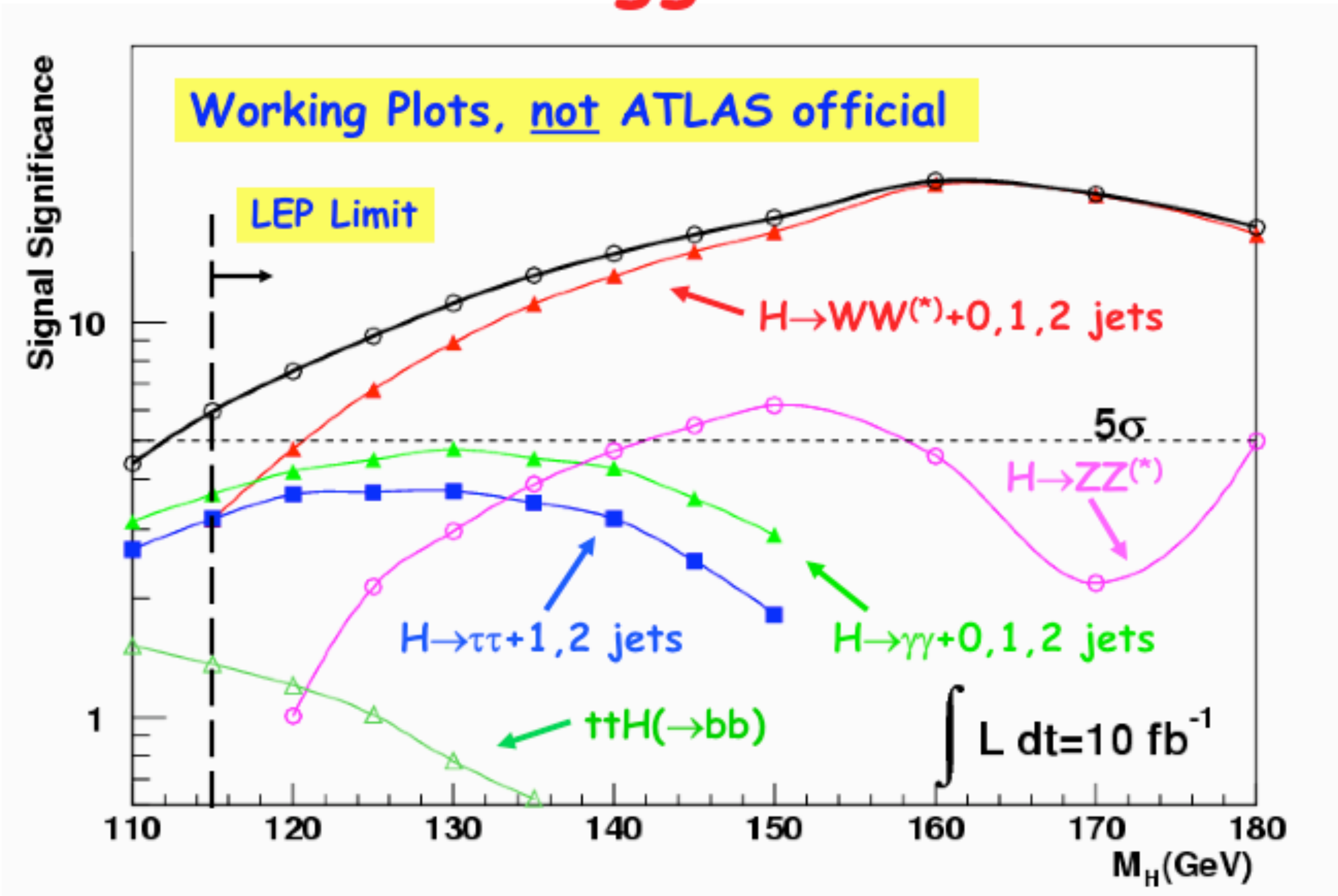
  $\rightarrow$ 0 events (expect:0.03 ± 0.01 $(W^{\pm}H)$, 0.54 ± 0.14 (background)).



Source	Uncertainty (%)
Jet Energy Scale	14
Jet ID	7
b-tagging	11
Trigger & e ID	5
EM Scale	5
MC Simulations	15
Total	26

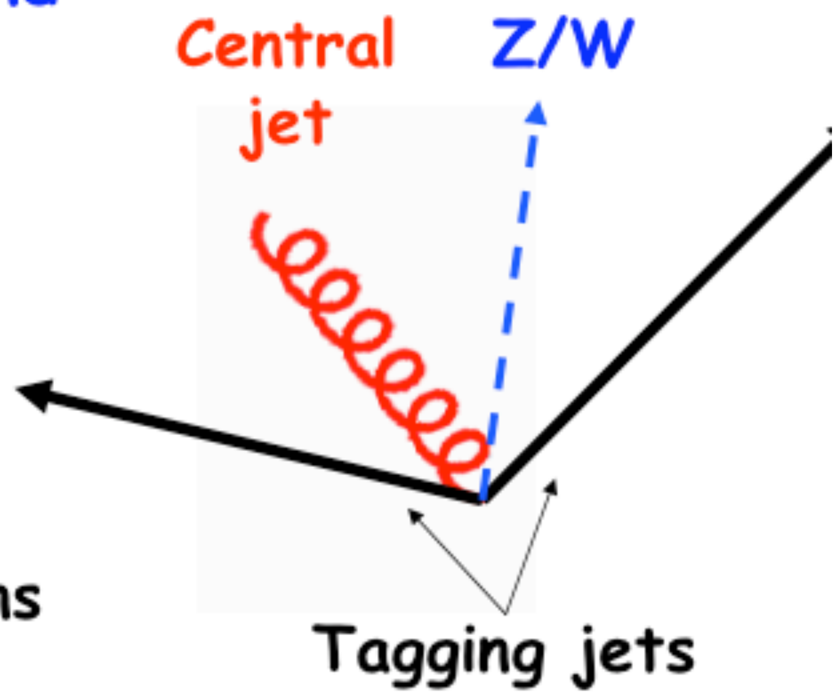
$\sigma(W^{\pm}H) \times Br(H \rightarrow b\bar{b}) < 12.4$ pb at 95% C.L. for $m_H = 115$ GeV.

Low Mass SM Higgs Potential at LHC



H+2jets (VBF) at the LHC (cont)

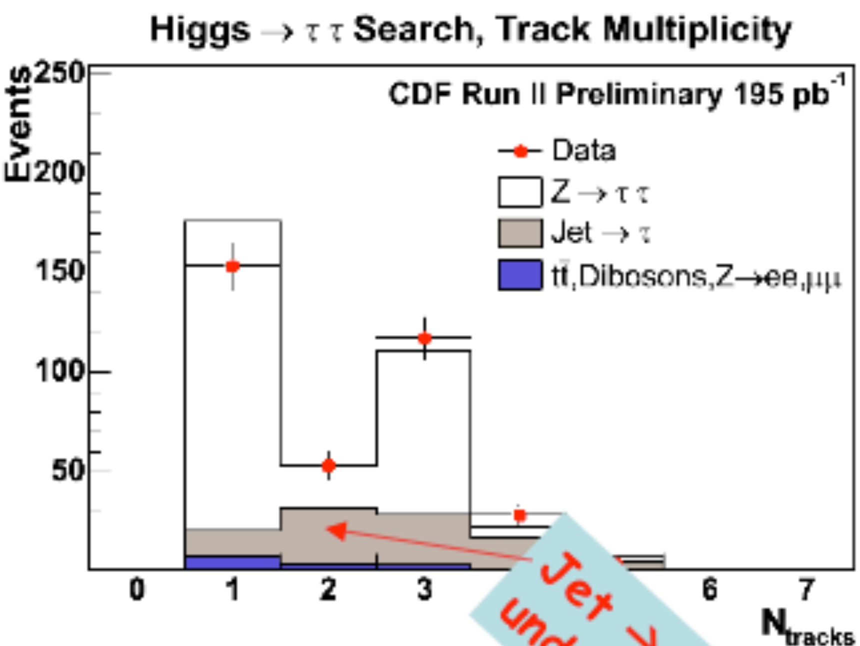
- Study additional (central) jet production to W + 2 forward and separated jets (tagging jets)
  - Cross-section dependence on separation in pseudorapidity between tagging jets
  - Rate of third jet
  - Angular correlations between tagging jets and central jet
- Comparison with QCD predictions
  - Test interplay between perturbative and parton shower approaches

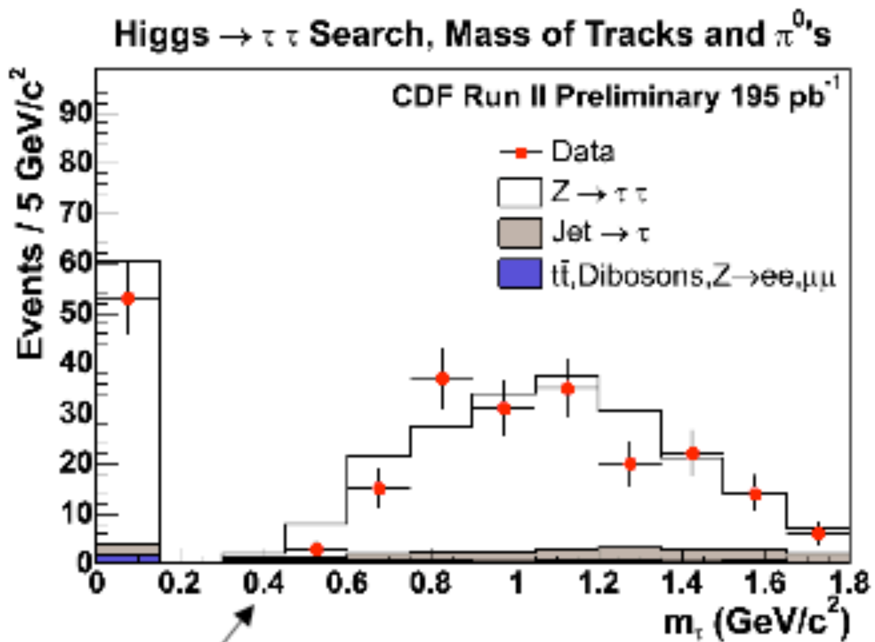


Outlook

- Higgs associated with jets play a central role in searches for Low Mass Higgs at the LHC
  - Need to extract reliably QCD backgrounds
    - Will rely on LHC data to extract QCD backgrounds
  - Tevatron plays a central role in validating MC tools, which will be extensively used at the LHC
- W/Z associated with jets are produced copiously enough at the Tevatron to study topologies relevant to H+1j and H+2j searches at the LHC
  - Cross-sections for W/Z+1,2,4 jets are large enough to investigate relevant corners of the phase-space
- Jet veto in $pp \rightarrow WW+X$ is central to Higgs searches with $H \rightarrow WW \rightarrow ll\nu\nu$ at the LHC

Hadronic τ signature





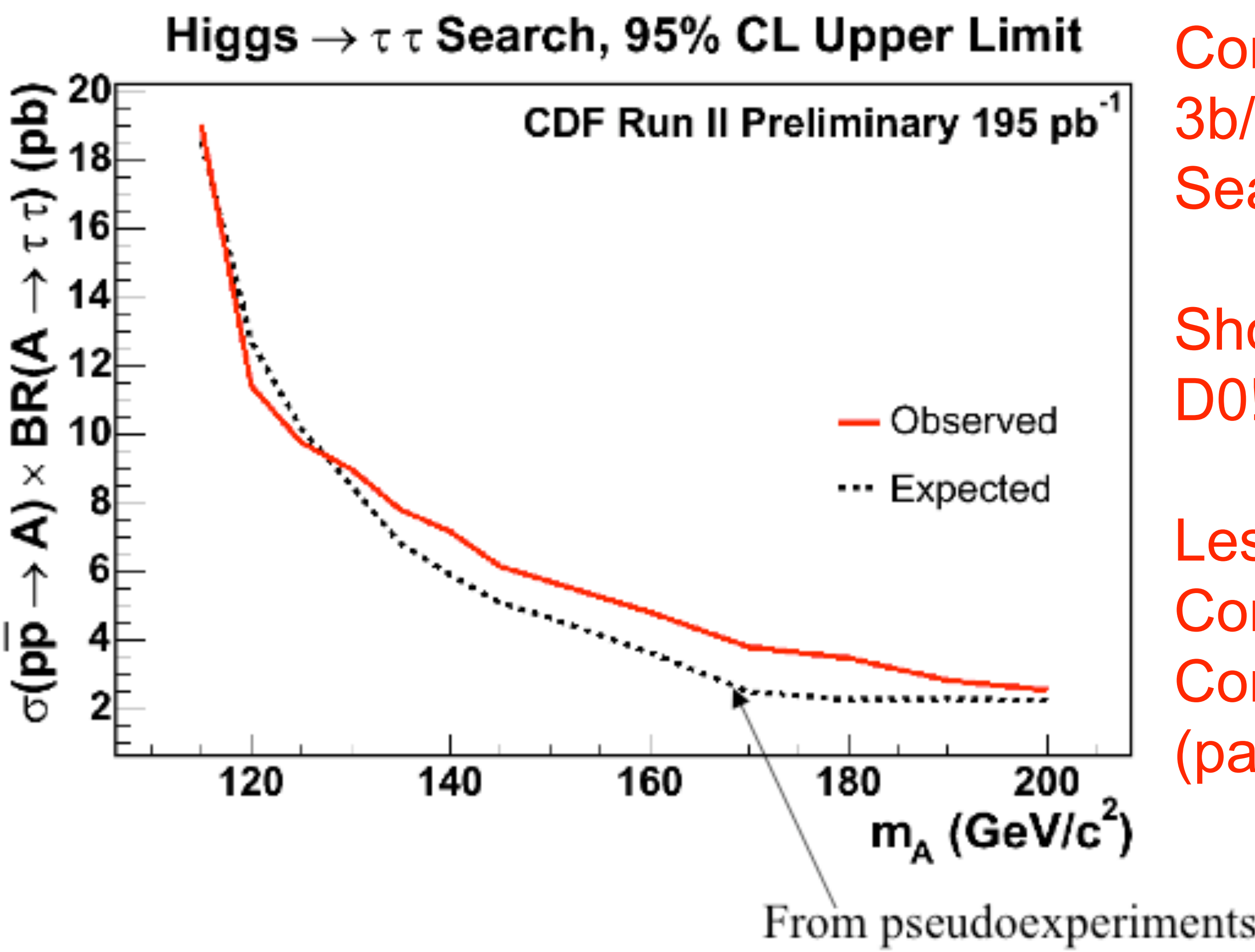
Jet → τ fakes under good control!

Nice 1, 3
track enhancement.

Only 1,3 track events.
Only events with τ_h ,
e/μ opp. Charge.

Fakes measured from incl. jet triggers.
Can do same at LHC?

Fit Results



Should also Combine with 3b/4b MSSM Higgs Search!

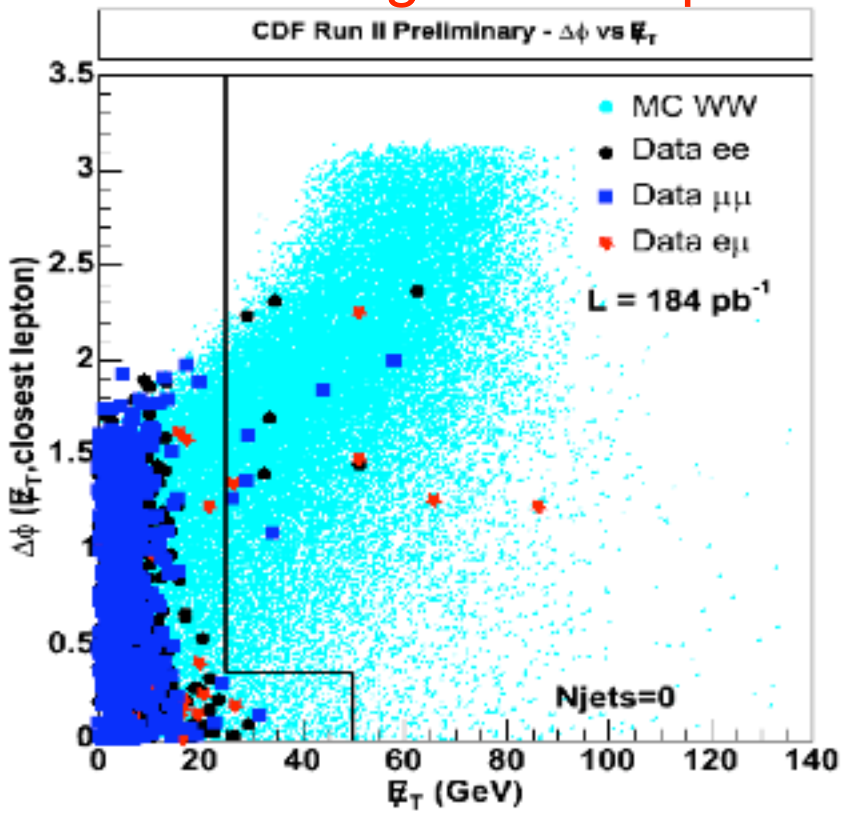
Should combine with D0!

Lesson from LEP: Combine early, Combine often (painful)

Starting point: WW cross section

Making steady progress on understanding diboson production

~200 pb^{-1}	ll: ee, eμ, μμ
WW	11.3 ±1.3
DY	1.82 ±0.4
WZ+ZZ Wγ	0.76 ±0.06 1.05±0.19
Fakes	1.08±0.49
Bkg	4.77±0.70
WW+Bkg	16.1±1.6
Data	17

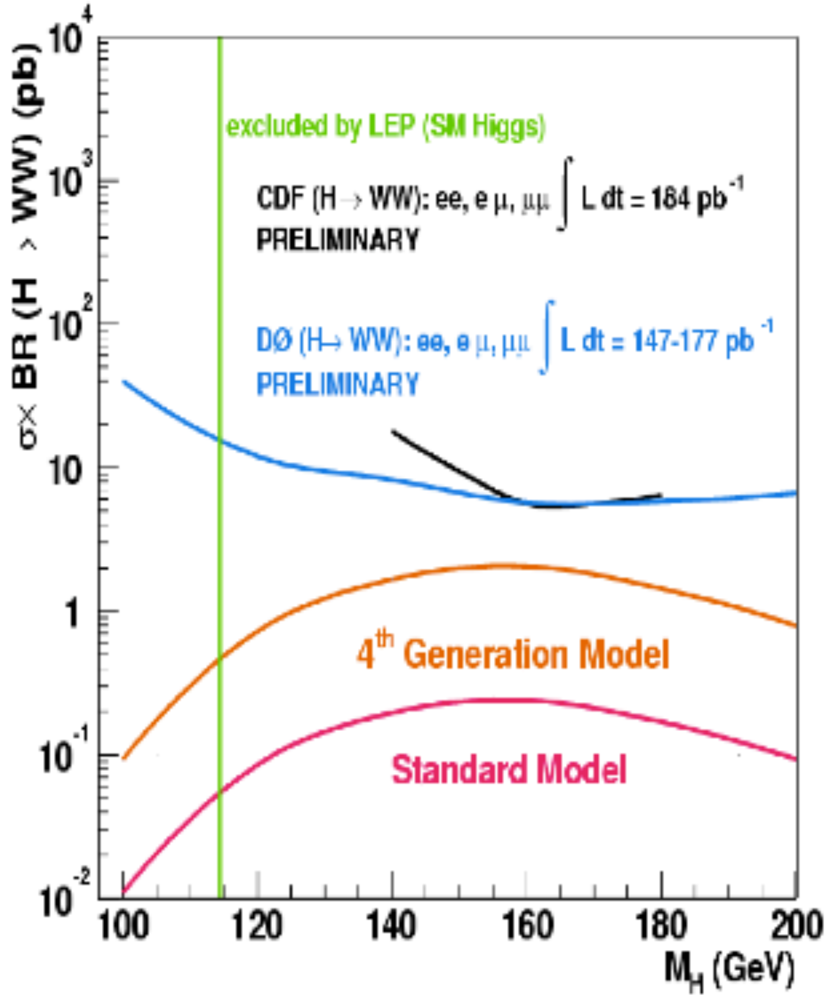


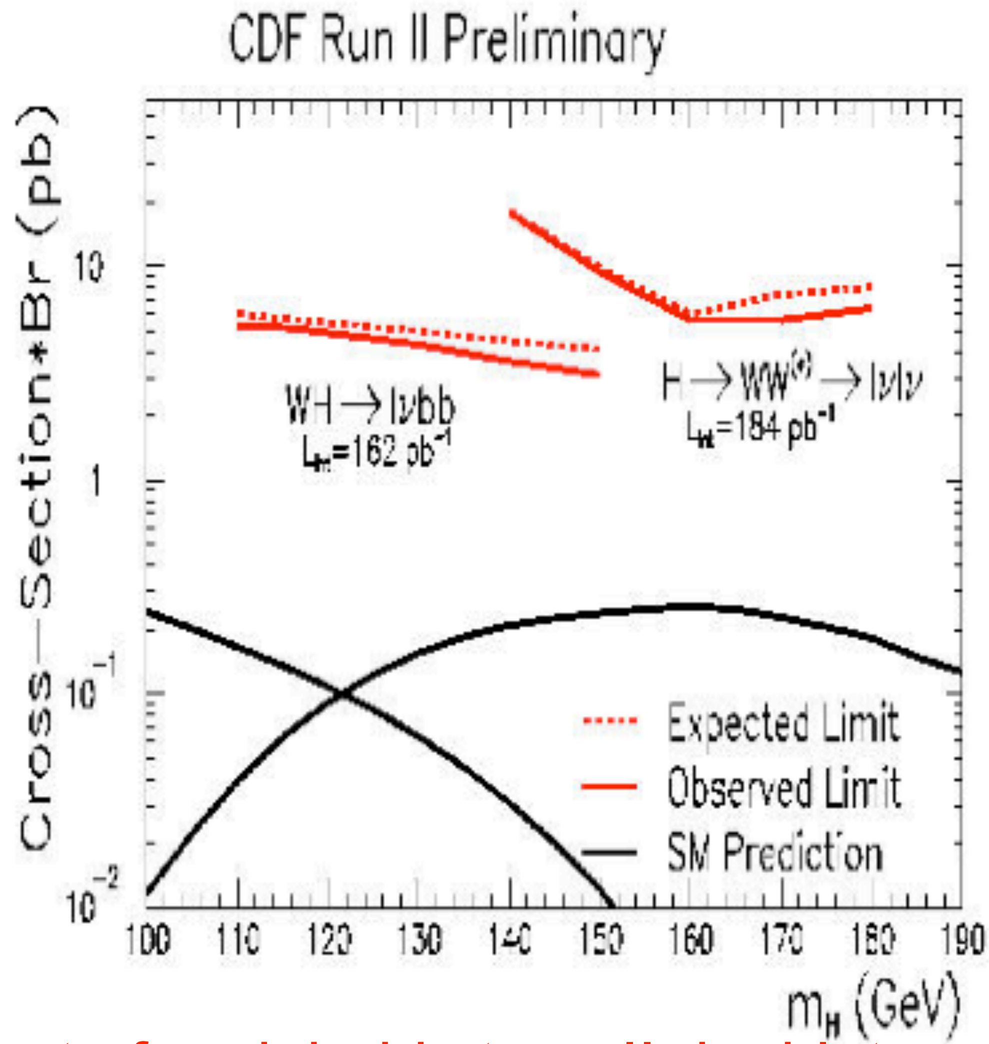
NLO (MFCM, Ellis& Campbell) σ^{WW}=12.5±0.8 pb

Would like to have MC@NLO with spin correlations

$$\sigma(p\bar{p} \rightarrow WW) = 14.3^{+5.6}_{-4.9}(stat) \pm 1.6(syst) \pm 0.9(lum)\ pb$$

CONCLUSIONS





Learned we are also sensitive to fermiphobic type-II doublets
See H. Logan's talk

Ok, now what?

- CDF & D0 should continue to push hard on Higgs analysis. It is largely complimentary to LHC and best way to develop tools and validate MC
- TeV can find 3σ SM light Higgs just before LHC
- MSSM, non-SM Higgs still possible
- Have a few good, little projects already
- Need people to suggest/work on more for successful workshop